USAID
FROM THE AMERICAN PEOPLE

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RESPONDING TO
The Water Crisis in Jordan

"

Jordan today stands face to face with the reality of potentially frightening water shortages. In a largely arid region, even the slightest change in water levels or quality has a significant impact on agriculture, industry, nutrition, and personal health standards. The hard reality is that Jordan is consuming more water than it has available from secure (annually renewable) sources. A water catastrophe is imminent, as groundwater resources will slowly dry up."

Embassy of the Hashemite Kingdom of Jordan,
Washington D.C.[i]

Introduction

Jordan needs to quickly implement some dramatic changes in water resources management. Groundwater resources are being overexploited because water is provided at almost no cost to agriculture and at very low cost to urban consumers. Aquifer water qualities have already deteriorated in places like Dhuleil and Hallabat and increasing soil salinity is making land less productive in some areas. Agriculture consumes 65% of the total water supply yet contributes only 2.5% of Gross Domestic Product (GDP).

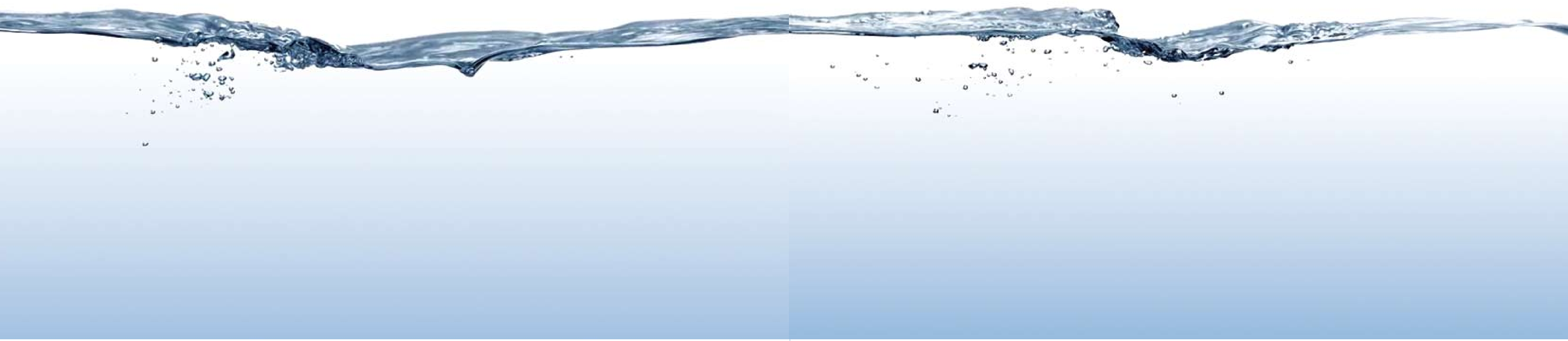
Given the priority of basic water needs (municipal) and the significant economic return from industry per cubic meter of water used, the available water supply should be provided to these two sectors as priorities. By 2020, expected sustainable water supply will only be sufficient to meet the projected demand for water from industry and municipal users, but not the demand from agriculture. Farmers need to be given options and opportunities to change from current practices. This needs to be approached judiciously to ensure that social equity concerns are addressed.

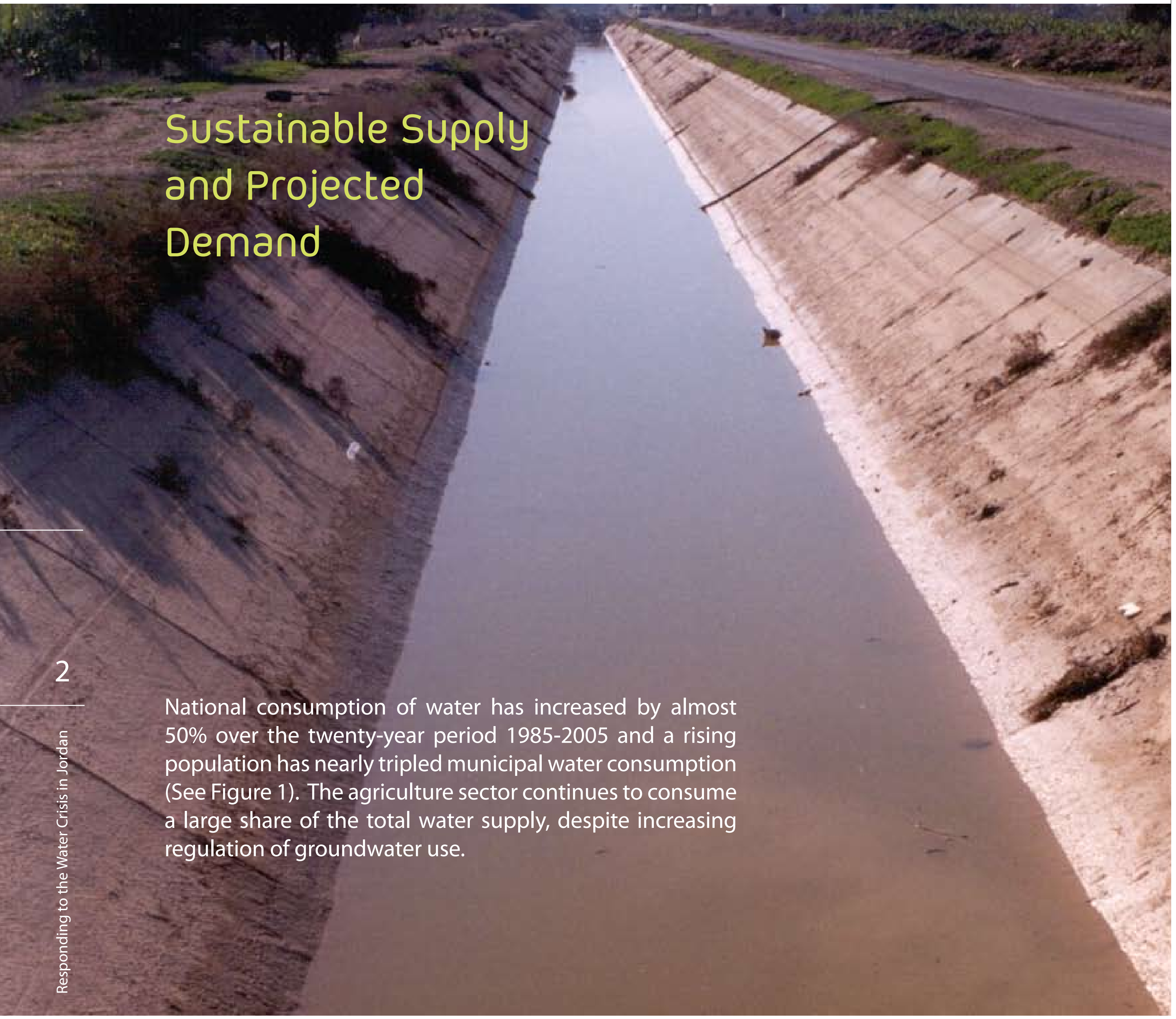
Immediate action is required to stop depleting Jordan's groundwater.[ii] Water managers have no choice – delay only increases the social and economic costs of satisfying future demands. The Government of Jordan (GOJ) is already developing all readily available and affordable sources of renewable water, and is enabling the delivery and use of treated wastewater and desalinated groundwater.

Proposed new water from the Disi aquifer and the Red Sea Dead Sea conveyors will not meet total projected demand and delivery costs will far exceed current water tariffs. Furthermore, the new supply is unlikely to be available for many years. The Disi aquifer conveyer will only satisfy 10% of current annual consumption. The proposed Red Sea-Dead Sea conveyor could provide up to an additional 65% of current annual consumption but the delivery cost will be very high and will have a major impact on the cost recovery of the sector at current water tariffs.

Fortunately, there are a number of efficiency measures that farmers and the public can adopt to optimize their use of water and help to mitigate the worsening consequences of over-extraction. The GOJ needs to act now to explain and enforce these measures. In the long-run, both the public and private sectors need to fully integrate the true value of water into their planning and investment decision-making process. The true value of water, like other natural resources, must account for alternative economic uses of water and environmental implications as well as seeking to balance the needs of future generations with the needs of the present.

The balance of this paper examines the components of the water crisis in detail in the areas of the current supply and projected demand, the competing users and the returns to the economy from these uses, future sources of water, and approaches to solving the crisis through four themes: Awareness; Policy, Law and Reform; Technology; and Commercial Practices.





Sustainable Supply and Projected Demand

National consumption of water has increased by almost 50% over the twenty-year period 1985-2005 and a rising population has nearly tripled municipal water consumption (See Figure 1). The agriculture sector continues to consume a large share of the total water supply, despite increasing regulation of groundwater use.

Figure 1. Historic Water Consumption 1985-2005 (MCM/Year)

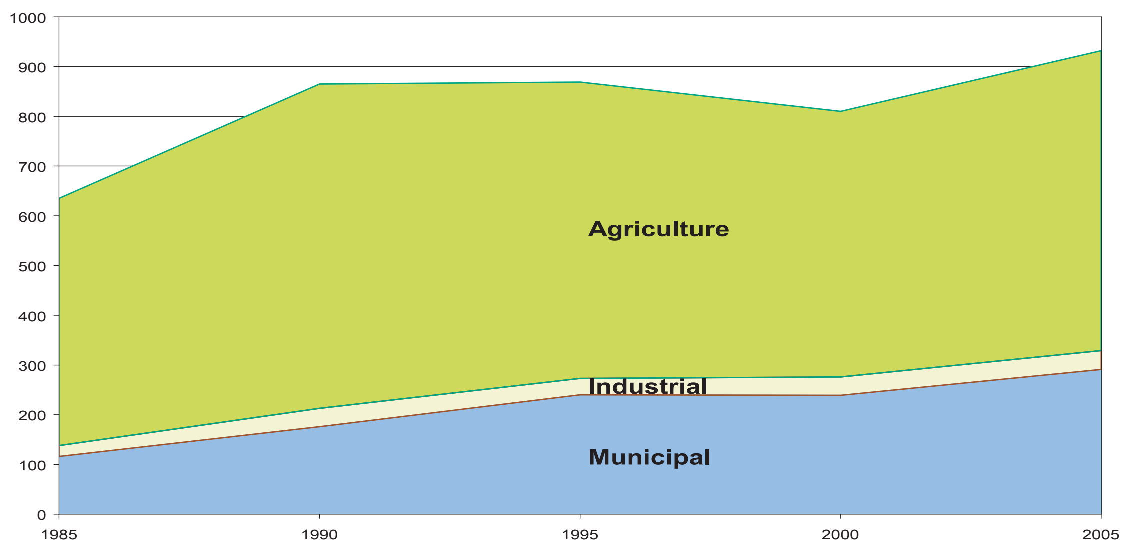


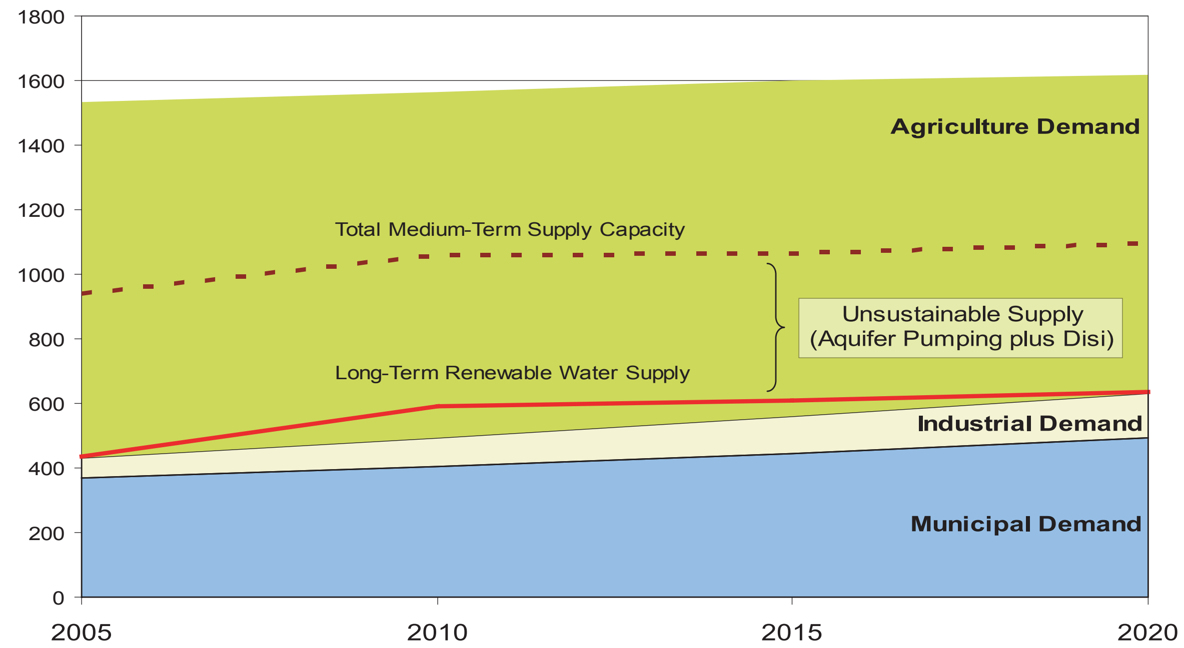
Figure 2 below, shows projected demand for water from municipal users, industry, and agriculture and the estimated renewable supply.[iii] Projected demand is based on population growth and productive capacity and accounts for improving distribution and irrigation efficiencies. Over the next 15 years, annual agriculture water demand, based on current cultivated land area, is forecasted to remain about 1,000 million cubic meters (MCM). Because of a growing population, however, municipal demand is projected to increase from 291 MCM in 2005 to almost 500 MCM by 2020. Note that the municipal demand projections in the National Water Master Plan (NWMP) do not consider recent Iraqi immigrants; which have likely increased municipal water demand by an additional 8%.[iv] Nor does it consider the newest commercial development projects in Amman including the high rise buildings and extended compound housing projects.

The solid red line shows the growth of all planned sources of renewable water supply – comprising surface water from rivers, springs and reservoirs; and treated wastewater. For current purposes, renewable supply excludes all pumped groundwater and water from the potential Red Sea-Dead Sea conveyor scheme. Ministry of Water and Irrigation (MWI) forecasts that by 2020, under the terms of the 1994 peace treaty, up to 50 MCM of fresh water will be available each year from Israel in addition to what is currently received under the treaty. Planned sustainable supply increases are only sufficient to keep up with increasing industrial and municipal demand over the next 15 years. The country is relying on unsustainable pumping of groundwater to supplement its renewable water supply.

The dashed line traces the "business as usual" supply of water forecast by the MWI, including water supplied by the planned Disi groundwater conveyor – an unsustainable source of water that will only supply a small part of Jordan's water requirements (see discussion on Disi). The gap between the solid red line and the dashed line represents unsustainable supply, i.e., groundwater depletion including brackish groundwater desalination. The MWI is forecast-ing groundwater extraction will decline between now and 2020 to meet what is commonly consi- dered to be the "safe annual groundwater yield" of 275 MCM. **Groundwater experts state that pumping of groundwater even at "safe yield" levels will eventually lead to the reduction of natural groundwater outflows, such as springs and rivers.** Current forecasts clearly indicate that total sustainable and non-sustainable water supply will continue to be insufficient to meet total potential demand using current production techniques.

Responding to the Water Crisis in Jordan

Figure 2. Projected Water Supply and Demand (MCM / year)



Competing Water Uses

"Our water status is a strategic challenge that we cannot ignore. We have to balance between drinking water needs and industrial and irrigation water needs. Drinking water is the foundation and the priority."

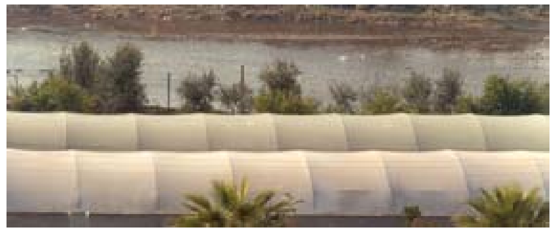
H.M. King Abdullah II,
November 7, 1999.

1. Agriculture

As Figure 2 shows, the main use of water in Jordan is for agriculture. Most farmers pay so little for water they do not properly value it. They waste water by not irrigating their crops as efficiently as they might and by growing low-value, water-intensive crops. The net result has been that agriculture uses more water and contributes less to the economy than other economic sectors. The amount of water used for irrigation increased by 20% between 1985 and 2003 yet agricultural returns increased by only 4.5% in constant prices over this period.

Agriculture is sustainable in the long-term only in the rain-fed areas of the highlands – covering two thirds of current total cultivated land in Jordan – and in the Jordan Valley.[v] Olives are the predominant rain-fed crop. Agricultural activities in the remaining cultivated land in the highlands (maximum of 60,000 ha) and the Jordan Valley (maximum of 43,000 ha) consumed 600 MCM of irrigation water in 2005.[vi] Currently, surface water and groundwater each provide 40% of irrigation needs with the remaining 20% sourced from treated wastewater.

Accounting for all planned sustainable and non-sustainable sources of water over the next 15 years, the MWI projects that 1,093 MCM of total water will be available in 2020, of which agriculture will continue to receive close to its current 600 MCM. However, the projected allocations to industry and municipalities are 118 MCM less than their 2020 requirements as estimated in the NMWP. If the GOJ gives municipal and industry demand priority then agriculture will only have 461 MCM available to it in 2020. Hence, accounting for all available planned sources of water, including 400 MCM of groundwater, farmers will have to reduce their current consumption of water by at least 20% to meet available supply in 2020. However, if Jordan chooses to safeguard its precious groundwater resources by stopping all groundwater extraction for irrigation, then irrigated agriculture will only be able to rely on the planned 175 MCM of recycled wastewater per year by 2020, any available surface water in the Jordan River Valley (JRV) and on precipitation.



Farmers can reduce their water consumption in a number of ways. The solution section in this paper describes some of these measures. The most fundamental measure is to grow crops that add more economic return per unit of water consumed. Warmer temperatures and more fertile soils in the JRV enable almost all crops grown to yield more per unit of water than if they are grown in the highlands.

The average economic return per unit of water consumed for all of agriculture is just JD 0.360 per m^3. This average hides significant variation. Among the 39 crops grown in different parts of the JRV, only ten sold for more than JD 1.000 per m^3 of water consumed in 2003 - the most valuable were tomatoes and cucumbers grown in greenhouses earning over JD 5.000 per m^3 of water.[vii] On the other hand, researchers estimate that the average return to irrigation with recycled water for a mixed cropping pattern of fodder, tree crops and field crops amounted to a mere JD 0.100 per m^3 in Wadi Mousa, though this approach is making productive use of treated wastewater for the local community rather than relying on additional quantities of freshwater.

However low current returns to agriculture are, the current price of irrigation water does not seem to be a limiting factor for any farmer, except those growing on the most marginal land. The Jordan Valley Authority (JVA) charges an average of JD 0.012 per m^3 for water.

The Water Authority of Jordan (WAJ) charges farmers pumping from private wells nothing for the first 150,000 m^3, JD 0.005 per m^3 between 150,001 m^3 and 200,000 m^3, and JD 0.060 per m^3 greater than 200,000 m^3. When this fee structure was established by the Groundwater Control Bylaw (No. 85) 2002, the amount of water pumped by some small farmers actually increased – to take advantage of the higher free water limit. In 2005, about 67 MCM of free water was pumped – equivalent to a one year supply of 100 liters per person per day for 1.8 million municipal residents, nearly one-third of Jordan population.[viii] Current irrigation tariffs need to be increased to encourage farmers to adopt more efficient irrigation methods and switch to higher value crops.

Current low tariffs, inefficient on-farm distribution systems and poor management result in over-watering of crops. Work by the Irrigation Advisory Service under USAID and the JVA in the 1999/2000 growing season demonstrated that a reduction in water can increase crop yields. For example, 11%-47% decreases in water applied to eggplant crops increased yields by 13%-22%.[ix]

Losses generated by WAJ and the JVA from providing water at below the cost of delivery represent a water subsidy to farmers. This subsidy was equivalent to JD 96 million in 2002 – half the agricultural GDP of JD 202 million.[x] Since industry and many municipal users pay JD1.000 or more per m^3, these users are, in effect, cross-subsidizing farmers. Accounting for any expected tariff changes and the cost of planned water supply and wastewater treatment projects, WAJ is expected to operate at around 70% of total cost recovery over the next ten years.[xi] Agriculture has become a costly public scheme – to employ an estimated 43,000 foreign workers and 46,000 Jordanians, at the expense of the future water security of the country.[xii]

2. Industry

Industry pays more for water than it costs WAJ and local municipalities to deliver.

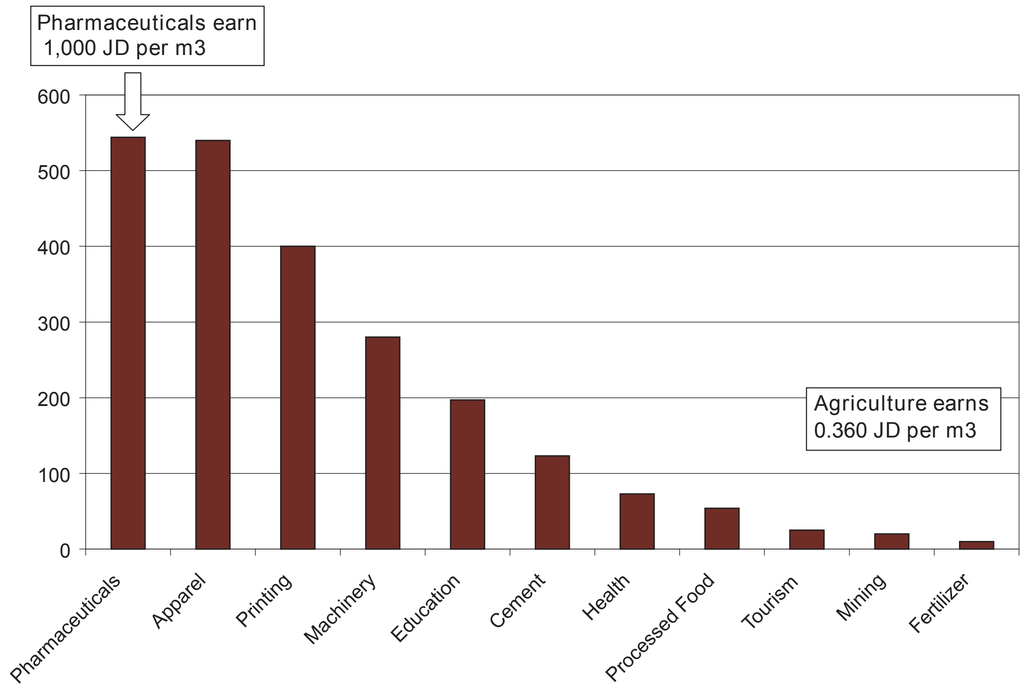
Industrial water tariffs range from JD 0.250 per m^3 pumped from private wells up to JD 1.800 per m^3[xiii] within Qualifying Industrial Zones and for the Potash Industry. Agriculture consumed 603 MCM (65%) of the total water supply while contributing just 2.5% to GDP in 2005. Conversely, industry consumed approximately 45 MCM (3%) and contributed 20% to GDP.[xiv] Therefore, agriculture requires 240 MCM to contribute 1% to GDP whereas industry only requires 2.5 MCM to contribute 1% to GDP. In other words, the economic return per unit of water from industrial use is one hundred times the economic return from agriculture.

Continuing the sectoral comparison, industry contributed 3,777 jobs and, at least, 7,000 indirect jobs per MCM of water consumed in 2004. Tourism contributed 1,693 jobs per MCM. Agriculture employed just 148 workers per MCM – half of whom are foreign workers – and contributed no income tax revenue to the treasury.[xv]

Figure 3 below, shows the economic return per unit of water consumed across selected economic sectors. Agricultural crop economic returns vary per unit of water used; the same is true for industrial uses. Traditional industries in Jordan – mining, fertilizer production and food processing – yield the lowest economic returns per unit of water among Jordanian industries. Newer industries such as pharmaceuticals, apparel and printing earn between JD 400 and JD 1,000 per m^3. The average economic return per unit of water consumed across all industry is JD 40 per m^3. Although tourism earns a modest JD 25 per m^3, it generates 12 times more jobs than agriculture per m^3. Education and health care are growing service sectors in Jordan and also yield relatively high economic returns. Compare all these sectors with the average economic return per m^3 of agriculture – just JD 0.360.

In the future, based on demographics, Jordan will need to create more than 50,000 jobs per year[xvi] to absorb new workers entering the labor force. From a water perspective, industry and tourism are the only sectors capable of absorbing these new workers and adding sufficiently high economic return to each cubic meter of water used. However, given current water allocations and the continuing depletion of existing groundwater resources, water availability for expanding these sectors will be constrained.

Figure 3. Economic Returns per Unit of Water Consumed in Selected Sectors (JD per m3, several years data)



Although industry may not need as much water as agriculture, the current allocations and pricing structure inhibit movement of water between these sectors. As the price of water moves closer to its true economic value, water will move toward higher return users, allowing for entrance of new firms and expansion of existing ones.

Future Sources of Water

Least-cost renewable sources of water are already being fully utilized in Jordan. Jordan currently has ten dams providing an annual supply of 225 MCM. As the Al-Wehdah dam on the Yarmouk River fully enters service (depending on water flow released from Syria) and the so-called "peace treaty water" is supplied to Jordan, the MWI intends to replace about half of the current supplies of groundwater with surface water as a source for municipal and industrial users. Storage capacity is relatively inexpensive to build but Jordan is running out of good sites. Reservoir outflow is ultimately limited by annual rainfall and groundwater abstraction and yield is expected to increase to just 300 MCM per year by 2020.[xvii]

An area of significant saving is the rehabilitation of municipal water networks in order to reduce unaccounted for water (UFW). UFW comprises equal shares of administrative and physical network losses and averages an unacceptable 30-50% of total water supplied throughout Jordan and 42% in Amman.[xviii] MWI has worked with donors to steadily reduce Aqaba and Amman losses in recent years. However, rehabilitation progress is slower than predicted requiring NWMP municipal demand projections to be revised upwards. Savings from further network rehabilitation are very cost effective – between JD 0.026 to JD 0.250 per m^3[xix], compared to the cost of new water supply.

1. Groundwater

Groundwater contributed 54% of the total water supply in 2005.[xx] About half of this groundwater supply is used, with surface and wastewater, by agriculture for irrigation.
As discussed earlier any groundwater extraction can cause reductions in natural outflows. Groundwater discharge at springs is about 20% of all surface water used in Jordan.[xxi] Even the 275 MCM annual yield considered "safe" by many observers will eventually reduce surface water flow. The rate at which natural outflows will decline cannot be readily estimated. However, groundwater extractions have exceeded 400 MCM[xxii] each year over the past ten years putting ten of the twelve groundwater basins in deficit conditions.[xxiii] Current groundwater extraction has now exceeded 500 MCM annually. Despite a new groundwater bylaw in 2002 setting limits on groundwater extraction through a regulatory scheme, more than a quarter of existing wells are unlicensed (there are estimated to be more than one thousand unlicensed wells in use compared to 2,779 licensed wells).[xxiv]

Annual extractions in the Amman-Zarqa groundwater basin are already nearly double the safe annual yield.[xxv] As a result of over-pumping, the water table is dropping throughout the Kingdom. Periodic water shortages in dry years mean that without reductions in extractions springs, streams and oases will continue to dry and water quality will deteriorate, as in the Dhuleil area. In a recent study of the 104 springs in the Shoubak area, 22 have gone dry and 47 show diminished flows since large-scale agricultural irrigation began in the early 1980s.[xxvi] Salinity has increased more than seven-fold between 1970 and 1998 at one observation well in the Amman-Zarqa basin.[xxvii] Over-pumping has already had significant impact on Jordan's environment. The Azraq wetland, the largest in the Middle East, used to attract up to half a million birds at any one time. Since groundwater pumping started in the 1980s, the water table has fallen on the order of 10 meters and the oasis completely dried up in 1992.[xxviii] Today, 10% of the oasis has been rejuvenated through the efforts of the Royal Society for the Conservation of Nature and the fact that WAJ pumps 1.5 MCM of potable water to the site each year.

DISI AQUIFER

Disi is an extensive fossil-water aquifer shared by Jordan and Saudi Arabia that should be managed very carefully as a strategic reserve.[xxix] There is no sustainable annual rate of extraction. The NWMP estimates an annual extraction of 125 MCM per year is technically and environmentally appropriate.[xxx] Currently, Jordan is pumping 77 MCM per year from the Disi aquifer. Saudi Arabia is extracting much more. The Jordan Times reported that 60 MCM of 77 MCM goes to four farms in the Disi area[xxxi] – a volume equivalent to all the water consumed by industrial estates, mining and heavy industry in Jordan. The remaining 17 MCM meets the peak demand of urban, tourism and industry users in the Aqaba Special Economic Zone – housing about 100,000 people. The Tabuk area of Saudi Arabia is currently pumping about 600-700 MCM annually.[xxxii] Both governments need to reach an agreement over their respective extraction of Disi water.

WAJ has recently permitted the Aqaba Water Company (AWC) to increase its annual withdrawal from Disi from 17.5 MCM to 35 MCM per year. The AWC plans to increase the capacity of the existing Disi pipeline to meet future water demand.[xxxiii]

The GOJ is considering building a pipeline from Disi to supply approximately 100 MCM annually to Amman. Subject to any options for renewal, the land leases for the four farms currently withdrawing 60 MCM from the Disi aquifer are believed to terminate in 2010.[xxxiv] Pumping water to Amman will not be cost-free; the

price of water from the private operator is estimated to be at least JD 0.700[xxxv] making it one of the most expensive water sources with considerable impact on the cost recovery ratio of the water sector. In summary, Disi is a costly, non-renewable source of water that will only meet a quarter of expected municipal demand by 2020.

2. Wastewater

Just over half of all households in Jordan have their wastewater treated, part of which is recycled for agricultural, industrial, and urban landscaping use. The GOJ is working to increase coverage over the next ten years. The volume of treated wastewater is projected to double to 245 MCM by 2020, of which 175 MCM will be available to replace fresh water used for irrigation.[xxxvi] Once the capacity to treat municipal effluent is in place, wastewater output is limited to the growth in municipal effluent.

The USAID-funded Reuse for Industry, Agriculture and Landscaping (RIAL) Project has demonstrated the potential water savings when large users implement environmental management systems and pollution prevention plans. The Pepsi Cola Co. bottling plant can potentially save 0.195 MCM per year; the Zarqa oil refinery can save 0.250 MCM per year and the Aqaba

Fertilizer Complex can save 0.103 MCM per year.[xxxvii] The maximum pay-back period for inves- ting in these savings is 2.4 years.[xxxviii]

3. Desalination

Currently, desalination of brackish groundwater by a few farmers and the WAJ produces 11 MCM of usable water per year. The new Zara Ma'in plant, funded by USAID, can provide upto 47 MCM/year to Greater Amman. However, increased large-scale desalination requires sea-water. The Aqaba Development Corporation is planning to desalinate up to 20 MCM/year by 2020 at an estimated cost of JD 0.580 per m^3. A larger plant of 100 MCM/year could produce water for as little as JD 0.468 per m^3 – adding at least JD 0.700 to pump the water to Amman gives a minimum total cost of JD 1.200 per m^3.[xxxix] Accessing new supplies of water via desalination is very costly.

4. Red Sea-Dead Sea Conveyor Project

The World Bank is managing donor contributed funds for a feasibility study for the construction of a canal/pipeline linking the Red Sea at Aqaba with the Dead Sea. To date, France, Greece, Japan, the Netherlands, and the U.S. have pledged funds towards the $15.5 million study. The canal/pipeline has two purposes: 1) use the gradient to generate electricity and desalinate about 850 MCM per year of water, of which 650 MCM per year would come to Jordan. Capital costs are estimated to be $3-5 billion. Including environmental mitigation, pumping and other operation and maintenance costs could push the total cost per cubic meter close to JD 1.200[xl], and 2) restore the volume of the Dead Sea to the historical average level. In addition to cost considerations, successful implementation will require continuous political cooperation among the three partners – Jordan, Israel, and the Palestinian Authority. Furthermore, the complexity and scale of the project mean that no water is likely to flow for another ten to twenty years.

Solutions

"Mining of renewable groundwater aquifers shall be checked, controlled, and reduced to sustainable extraction rates. Mining of fossil aquifers shall be planned and carefully implemented."

Jordan's water strategy 1997

To continue growing its economy in a sustainable manner, Jordan needs to act now to optimize utilization of its water resources. The answer is not simply to borrow the equivalent of 24% of current GDP in order to pay for the minimum expected cost of the Red Sea-Dead Sea Conveyor project.[xli] Repayment costs will place a significant burden on Jordanian water users and taxpayers. An immediate Government of Jordan focus is required on demand-side management. Demand-side management refers to a series of techniques, practices, and policies covering public awareness, laws and regulations, technology, and economic incentives to better conserve and sustain water resources.

The Government and people of Jordan can jointly implement appropriate demand management solutions to reduce the threat of running out of water through four inter-connected themes: Awareness; Policy, Law and Reform; Technology; and Commercial Practices.

1. Awareness

Creating awareness among the Jordanian public and decision makers is the first step towards behavior change and lays the foundation for policy change. For example, if a high percentage of the population knew that two-thirds of all water resources go to agriculture but contribute very little to the country's economic growth, an increase in irrigation tariffs would receive more public support. The true value of water is not properly understood in Jordan, nor is the cost of water delivery, or the costs and benefits of alternative approaches to water management. Once a robust foundation of knowledge is created among all concerned parties, the challenges will be easier to manage and will be more likely to encourage prompt action.

Audiences and awareness mechanisms must be identified. The target audiences are the public and private sectors, and the general public and can be both technical and non-technical. The private sector includes farmers, industry leaders, small and medium sized businesses, associations, chambers and non government organizations.

Messages should be prepared and disseminated at multiple levels once audiences are identified and current levels of knowledge ascertained. Messages can include, but are not limited to:

- The need to collaborate among all concerned Ministries (Planning, Water and Irrigation, Agriculture, Environment, Tourism, Industry and Trade, and Heath) on policy, economic, and social concerns related to water issues, especially for the inter- and intra-sectoral movement of water.

- The relationship between water sustainability and cost, and social and economic development in Jordan, i.e. the impact of worsening water scarcity on Jordanian's way of life.

- An understanding among water users of existing water allocations and attendant problems. Maximum impact will be achieved if the background knowledge is packaged with clear concise information on what social, economic, and political actions are needed to cure the root causes of the problems.

- Concrete suggestions on economically cost-efficient measures every individual can implement to reduce water demand.

- The need to properly value and maximize the return from each cubic meter of water resources used. For example, what is the appropriate price for Jordan's groundwater applied for irrigation of local farms?

- Consistent enforcement of regulations, policies and codes across all water users is essential for voluntary compliance to occur.

Delivery of messages can be through many avenues, mass media, associations, chambers, schools, universities and water delivery utilities (water companies, WAJ and JVA). The impact of messages can be significantly enhanced through delivery by the highest levels of Jordanian Government. Many of the above described actions are currently being implemented by USAID and other donor activities in collaboration with the GOJ. Again, highest-level GOJ support can accelerate implementation and increase results.

2. Policy, Law and Reform

A strong comprehensive policy and legal structure is the foundation upon which an effective regulatory body is built. There are many good policies, laws and regulations now in the water sector but additional reform measures are quickly needed. Such a foundation will permit transparent enforcement of laws and regulations and will thereby make a major contribution to ensuring Jordan's water is used efficiently and delivers high economic return per cubic meter consumed. Policy and legal reform measures urgently needed include:

- Policy and law to clarify and re-define the roles of Ministry of Water & Irrigation, Water Authority of Jordan, Jordan Valley Authority and other ministries (Health, Environment, Agriculture, Industry, and Tourism) with respect to water resources management: resources monitoring and allocation.

- Policy and law to equitably allocate transferable surface and groundwater rights to farmers to permit intra- and inter-sectoral transfers of water. Jordan Valley farmers would know in advance their allocation for the crop season and plan accordingly, subject to contingency provisions for unanticipated drought. Farmers could sell part or all of their surplus annual water right to other farmers or to industry. The GOJ could buy highland groundwater rights at market prices to reduce withdrawals from aquifers under stress. For example, farmers aged 60 years and older in the Mafraq region pump 36 percent of the groundwater for agriculture.[xlii] The GOJ could buy their rights as a form of pension and thereby provide some incentive to retire.

- Policy and law to provide incentives for farmers to grade agricultural produce by quality, sort by size and conformity, and practice proper post-harvest handling and transport, thereby increasing product quality and lengthening shelf life. This will bring increases in profit, which will enable farmers to upgrade or buy new technology and also be able to better afford an increased water tariff that more truly represents the value of water consumed.

- Removal of tariffs on imported crops to promote transition to crops with higher economic returns per unit of water used. For instance, growing bananas is a commonly cited but not unique example of an egregious waste of water to produce a crop that can be imported significantly cheaper than it can be produced in Jordan. Jordan can no longer afford such uneconomical use of scarce water supplies.

- Removal of municipal taxes and fees from produce not passing through wholesale markets, e.g., some export produce and produce sold directly to retailers. As water tariffs increase and quantitative restrictions and customs duties on imported vegetables and fruit are removed, farmers will have an incentive to switch to higher value, water efficient crops. The Jordan Valley has a significant comparative advantage by being able to harvest, and therefore export, fruit and vegetables at least two months before the growing season elsewhere in the Middle East and Europe. However, small farmers will need substantial training and support to make this transition.

- A law to permit the formation of groundwater basin water users associations. These associations could participate with the government in setting withdrawal limits, as well as allocating water rights among association members. Practice has shown that local communities are in the best position to decide on the appropriate use of public goods, e.g., similar to traditional tribal control of water wells in the Hijaz. In the Jordan Valley, the JVA could deliver bulk surface water supply to associations who then allocate the water more efficiently to their members.

Efficient water use will only become common practice when a strong consolidated water resources regulatory organization is in place to support compliance with the legal structure and there is a tariff schedule based on the true value of water. Stronger enforcement of laws and regulations can make a major contribution to relieving water shortages today. Actions could include:

- Unsustainable extraction of groundwater needs to stop in order to prevent permanent economic and environmental harm. Jordan's groundwater by-law 85 was created to protect and monitor the country's precious groundwater resources. Under this by-law, the GOJ has certain responsibility to collect fees for legal wells. Yet fees from the majority of wells used for agriculture purposes are not collected. Without fees coming back into the sector from users, the GOJ will be subsidizing water in perpetuity. In addition, hundreds of illegal wells pump water daily in Jordan, which stresses the country's aquifers. The by-law also requires the government to establish appropriate pumping reduction plans for aquifers under stress; currently 10 out of Jordan's 12 groundwater basins are showing a deficit, the other two are close to their limit, and the situation will only get worse. Groundwater management plans need to be established and implemented in order to begin to slow this dramatic decline in groundwater.

- Revision of WAJ/JVA bulk tariff setting mechanism to reflect the real value of water, based on the high cost of developing and providing water from new sources. Low tariffs encourage waste and low-value uses and provide no incentive for efficient water distribution and use by water delivery authorities and customers, respectively. An efficient mechanism to supply the basic water quality and quantity requirements of low-income families should accompany any adjustment in municipal water tariffs. As fiscal constraints reduce the level of public funding available for subsidies, users will have to pay a larger share of the costs. By charging industry more than the full cost of delivery, to subsidize urban and agricultural water users, the GOJ is currently deterring investors from developing certain types of industry in Jordan; industries that can add more economic returns and employ more workers than agriculture.

- Adoption and enforcement of draft building and plumbing codes that set maximum water flow limits and minimum quality standards for plumbing fixtures. Strict enforcement of the building code, particularly with regard to shower heads and toilet flush capacity, could save a minimum of 10% of municipal water use each year.[xliii] Unfortunately, new construction has added 50 million square meters of floor space in Jordan over the past five years. Much has been built without these water conservation fixtures.[xliv] Banning the importation and local manufacture of inappropriate high water use fixtures will facilitate enforcement of the codes.

- Modification of policy and implementing regulations (incentive structure) to encourage the use of innovative approaches to harvesting of water from rainfall. Demonstrations have shown that Jordan can make better use of its rainfall.

- Consolidation of regulatory functions scattered across several ministries and offices, and separation of regulation from operational functions must be completed. Consolidation will reduce redundancy, increase efficiency, minimize functions, and separation will reduce the temptation to overlook operational deficiencies because both functions are implemented by colleagues in the same ministry.

- New policy and implementing regulations requiring certification of water and wastewater treatment plant operations and maintenance staff, to be phased in as trained technicians become available. Trained staff will ensure water treatment plants operate properly for their design lifetimes while delivering high quality water to customers.

- Modification of policy and regulation to permit water allocation among users in Jordan by considering return per cubic meter used while ensuring satisfaction of basic domestic water needs. This action will offer several benefits: higher returns per cubic meter of water used will increase ability to pay tariffs in line with the true value of water, reducing stress on the GOJ budget caused by high water subsidies; water will move away from agriculture, that employs a high percentage of imported labor, to industrial uses, that employ a high number of Jordanians; water will be used to highest efficiency, with minimum waste; and efficient water use will complement development of new water sources and better protect existing ones.

Institutional reform is needed to provide optimum management of water resources through policies, laws, regulations, and tariff structures that reflect the true value of water and the increasing competition for access to water; all users need to pay a socially optimal price of water.

3. Technology

GOJ must facilitate adoption of new innovative and proven technology to produce, distribute, and use/reuse water more efficiently. Such technology can increase levels of economic production without increasing water use or waste. Training should be provided on how to use the technology properly: new meter reading systems for urban settings; electronic data acquisition for management of infrastructure components; software for technical, financial and economical processes to generate information for decision- makers; management and maintenance of drip irrigation systems; and water delivery schedules that fit the needs of customers. Access to capital, when coupled with higher water delivery fees, training and awareness, will accelerate the adoption of improved technology and management practices. The role technology can play is shown in the following:

- Farmers will invest in new technology and provide better management when the incentive structure requires the investment. Higher water delivery fees change the incentive structure in the right direction. For example, best practice hydroponic strawberry growers are able to reduce their water consumption per kilogram of yield to six percent of their irrigated strawberry crop neighbors. Modern Jordan Farms, with large export markets, desalinates its own brackish water at a cost of JD 0.210 per m^3, plus the cost of pumping – demonstrating a willingness to pay 17 times more for water than the JD 0.012 per m^3paid by small farmers to the JVA for irrigation water.[xlv]

- Potential benefit from the provision of soft loans or grants to the local fixtures industry to retool for low water use fixtures; to industries, agriculture, municipalities, and homes for implementation of technologies and approaches that conserve; or to industries and agriculture that reuses water, should be assessed. Technologies should be practical, environmentally safe, and have quick recapture of investments.

- Adoption of water saving fixtures and equipment available for industries, municipalities and homes will be encouraged by enforcement of building and plumbing codes. In conjunction with building code enforcement, public awareness campaigns should be launched to motivate purchase and use of the new fixtures and equipment.

- Better and more appropriate use of technology can increase economic productivity without increasing water use or waste. For example, expanding the use of treated wastewater is catching on fast in Jordan and shows great potential for agriculture, industry, and urban landscapes. Industry represents nearly 20% of Jordan's GDP. Some industries consume significant amounts of water (e.g., apparel, food processing, and beverage industries) and pay up to JD1.8 per cubic meter. The private sector is funding construction of a wastewater treatment plant in the Al Hassan Qualified Industrial Zone (QIZ). The treated wastewater will be sold for reuse within the QIZ, thereby reducing demand for fresh water and reducing the volume of liquid wastes needing disposal.

- Alternative water supplies, such as from brackish water desalination programs, and expanded use of treated wastewater reduce demand on scarce fresh-water sources. Treated wastewater irrigation of fodder and tree crops in Wadi Mousa has significantly increased economic returns from the land for local Bedouin farmers. Where economically practical, treated wastewater can be used to replenish the aquifers.

- Large-scale watershed management programs include water harvesting (collection systems) in both rural and urban landscapes. USAID is supplying grants that provide seed capital to community organizations. This capital is then loaned to farm families, cooperatives, farmer groups, or individual households to conserve water or improve water efficiency according to their needs. This small-scale, decentralized approach spreads technology benefits into some of the more isolated corners of Jordan.

- The use of information technology for improved data and information management systems increases efficiency of employees and improves decision making.

4. Commercial Practices

Organizations producing, distributing and treating water need to operate using best commercial practices within a regulated water market. More business-like approaches to water resources management will save water and reduce GOJ cost subsidies. Water utilities must run like businesses with a focus on customer service, providing a quality product that is properly valued and paid for by customers. The extremely high losses within Jordan's water distribution systems (up to 50% in some areas) must be drastically reduced and quickly brought in line with international best practices.

The JVA and the WAJ need to transition from subsidized and inefficient providers of a public service to commercial providers of a valuable commodity. Perhaps most importantly, all private and public operators need to be able to set tariffs for their customers, approved by a regulatory authority, while ensuring the poor receive water for basic needs. Benefits from adoption of commercial practices include:

- Reductions in man-power required per unit of water delivered to customers.
- Increases in revenue from outsourcing billing, collection and customer service to private companies.
- Integration of technology into operations and management to substitute for labor, leading to increased efficiencies in water deliveries, reductions in water losses and reduced costs.
- Introduction of innovative approaches to reducing water demand, thereby increasing water supply, e.g., rebate programs for retrofitting low water use fixtures.

Providing operators producing, treating and/or distributing water the authority to operate as a commercial business will reap benefits. With the Kirbet As-Samra Wastewater Treatment Plant the GOJ has successfully introduced private sector participation into the bulk water treatment market. The Aqaba Water Company and Miyahuna are bringing commercial business practices to the retail distribution and collection of water and wastewater market segments, respectively. In Aqaba, service has improved, losses reduced, and the company is making a profit, which it is using to further improve service and infrastructure. Lessons learned need to be incorporated in an expansion in the use of commercial business practices in water resources management.

Water pricing should be one of a suite of tools to guide water allocation and investment decisions by WAJ and JVA. With increased income both organizations can improve their organizational efficiency, reduce debt, and implement improvements to reduce the volumes of unaccounted for water, whether due to administrative or physical causes. More efficient management of the existing large-volume water supply distribution network will contribute substantial water savings. Water tariffs should better reflect not only the financial returns possible from alternative uses of water, but also environmental and intergenerational values (i.e., the value future generations will place on water availability compared to this generation).

Adjusting water tariffs need not have the same adverse effects on farmer income as the recent increase in fuel prices. There were no readily available short- or medium-term sources of energy; therefore, people bore the full effect of fuel price increases. However, consumers, including farmers are able to adjust their water-use behavior in the medium- to long-term. Studies show that simple changes in operation and maintenance of on-farm irrigation systems can reduce Jordan Valley irrigation water consumption. The NWMP accounted for likely irrigation method and application improvements in its projection of agricultural water demand. Improvements in overall efficiency were forecast to be 12% in the Jordan Valley and 6.7% in the highlands between 1998 and 2020.[xlvi] Based on this forecast, further gains on the order of 10% in total irrigation efficiency in the Jordan Valley are conceivable.

IMMEDIATE ACTIONS REQUIRED TO ADDRESS THE WATER CRISIS

Enforce Groundwater Control Bylaw (No. 85) 2002 – enforce ground-water basin extraction limits and close illegal wells.

Re-structure irrigation and pumping tariffs to reflect, at a minimum, the full cost of delivery of government-supplied surface and ground waters. Eliminate free pumping from private agriculture wells.

Adopt and enforce water-efficient building and plumbing codes.

Accelerate rehabilitation of municipal water delivery and management systems to reduce both physical and administrative losses.

Implement successful water harvesting practices outside of pilot project areas.

Implement a public awareness program showing depletion of groundwater and its potential consequences and inform farmers of the current problems with irrigation.

Implement the recommendations on reform of agricultural produce marketing.

Facilitate formation of water user associations and examine benefits of variable water right trading.

Conclusion

Current renewable supply only meets about half of total water consumption in the Kingdom. This is a crisis. More importantly, extrapolating current trends, demand is forecast to exceed planned renewable supply by almost 1,000 MCM, or 250%, by 2020. For the present, the shortage of supply is met by unsustainable groundwater extraction. However, this approach cannot be long-maintained. Groundwater extraction at the safe yield level eventually leads to the reduction or cessation of natural groundwater outflows, including springs and rivers, and hence can reduce surface water flow, itself a major source of renewable water. Attendant with significant reductions in aquifer water levels is risk of permanent damage to the aquifer.

Both the public and private sectors need to better integrate the true value of water into their planning and investment decision-making process. The cost of water, like other natural resources, should reflect its real value, which includes consideration of alternative uses. These include environmental uses, and should seek to balance the needs of future generations with the present.

Like any scarce resource, as the price of water moves closer to its true economic value, consumption will move toward more productive economic use. Water use will shift from less efficient farming techniques to high value crops irrigated with efficient technology and industry. On average, industry derives JD 40 income from every cubic meter of water used – compared to JD 0.370 per cubic meter from agriculture. Artificially allocating water to agriculture through subsidized low tariffs and restricting its availability through high tariffs to industry will deter investment and decrease the potential for employment opportunities.

Based on demonstrated experiences in other countries it is reasonable to assume that an annual reduction in municipal water use each year over the next ten-year period is possible in Jordan. This reduction could potentially offset new demands resulting from population growth and at a favorable cost when compared to developing new supplies. This is estimated to increase to approximately a 10% savings of annual demand after ten years which corresponds to approximately 45 MCM per year in 2018. The Zara-Ma'in project is designed to provide an average of 38 MCM/year at a construction cost of US$ 120 million in addition to the needed operational expenses.

Any new supply includes a delivery cost that is unaffordable by farmers using current cropping practices. Agriculture in the highlands will eventually have to depend on rainfall and limited irrigation with treated wastewater. The Jordan Valley will use treated wastewater, surface water in excess of domestic and industrial demands, and desalinated brackish water to produce high-value, water-efficient horticulture.

Water is a driver of development affecting all aspects of life: social, economic, and political. Increased shortages of water and decreasing water quality due to demand pressure on the system could result in poor health and social unrest. Budgetary outlays for water and health will increase. The overall health and productivity of the labor pool and of Jordan's children will deteriorate. Costs of doing business will rise, affecting the competitiveness of Jordan's economy. A failure to address equity issues in water may lead to political unrest. The poor and lower classes are the first to feel the impact of water shortages and of degraded water quality. These impacts are being felt today and in some locations they will worsen significantly within five years.

Without action starting from the highest echelons of the GOJ, the consequences of "business as usual" in the water sector will become increasingly severe and will impact social and economic development in Jordan.

Jordan and the U.S. have a strong history of collaboration in the water sector stretching back over 50 years. The U.S. will continue to partner with Jordan to improve management of water resources and will continue investing in Jordan's water infrastructure. However, investments in infrastructure must be coupled with investments in water conservation, more rationale allocations for water use, and enforcement of sound water law and regulation. Without this, Jordan's promising future growth and development will be significantly constrained.

The time for action is now.

TECHNICAL ANNEX AND ENDNOTES >

TECHNICAL ANNEX AND ENDNOTES

[i] http://www.jordanembassyus.org/new/jib/factsheets/environment.shtml - April 2007
[ii] Calculation involving consumption, supply, demand, and GDP are based on data provided in the tables in this Annex.

[iii] **Table 1. Historic Water Consumption by Sector (MCM)**

	Municipal	Industrial	Agriculture	Livestock	Total
1985	116	22	497	4	639
1990	176	37	652	5	870
1995	240	33	596	9	878
2000	239	37	534	7	817
2005	291	38	603	8	940

Source: Volume 3, Chapter 1, Figure 4. for 1995 and 2000, Table 2 for tourism (1995=1996) WAJ Annual Report 2005, Table 6.

Table 2. Projected Gross Water Demand, including Physical Losses (2005-2020) National Master Water Plan, Scenario One (MCM)

Demand	Agriculture	Municipal	Industry	Tourism	TOTAL
2010	1072	405	77	10	1564
2015	1040	444	100	16	1600
2020	983	493	120	20	1616

Source: Volume 3, Summary, Tables 2, 4, 5 and 6 of the 2005-2020 National Master Water Plan

Table 3. Actual and Projected Supply by Source (Allocation) MCM

	Surface Water	Peace	Wehdah Dam	Treated WW	Sea Desal	Total Sustain	Gnd water	Disi	Desal ndwt	Not Sustain	Total Supply
2005	251	50	0	83	0	435	419	77	10	506	941
2010	239	47	133	153	19	591	377	66	25	468	1059
2015	232	56	116	181	22	607	344	66	45	454	1061
2020	234	50	119	207	28	637	300	98	59	457	1094

Source: 2005 figures from WAJ Annual Report 2005, Table 6; 2010-2020 figures from Water Information System at the Ministry of Water and Irrigation, calculated March 2007

[iv] The United Nations High Commission for Refugees estimates the number of Iraqi refugees in Jordan to be 750,000 by early 2007, http://news.bbc.co.uk/2/hi/middle_east/6562601.stm#map. Assume consumption of 100 liters per day resulting in an additional municipal consumption of 27 MCM per annum. Assume 2007 municipal consumption of 320 MCM. Therefore, 27 MCM represents 8% of estimated municipal consumption in 2007.

[v] *Toward More Efficient Agriculture Marketing and Production in Jordan*, DAI for USAID, May 2006, page 22

[vi] *NWMP 2004*, Volume 3, Summary, page 27

[vii] DAI (2006) ibid, Table 9, page 26

[viii] Estimate of free water and example provided by the USAID-funded Groundwater Project at the MWI.

[ix] *Strategic Management of Jordan's Water*, Ross Hagan, Water Resources and Environment Office, USAID, 2006, Table 2, page 10.

[x] *Investment Development Theme – Agriculture*, Jordan National Agenda, June 2004, slide 36

[xi] *Pricing of Water and Wastewater Services for the Water Authority of Jordan – Cost Recovery Scenarios and Action Plan*, November 2004, EcoConsult, Table 33, page 54

[xii] 2003 Employment figures provided in National Agenda, ibid, slide 20

[xiii] According to the Foreign Investors Association and Jordan Garment And Textile Exporters (JGATE) association…

[xiv] Industry comprises mining and large industrial or manufacturing plants, including industrial estates. However, note that smaller scale manufacturing draws on municipal water supply. Therefore the industry category of water use does not include all manufacturing.

[xv] Department of Statistics 2004 Household Census reports employment as follows: Agriculture (45,844), Mining (10,026), Manufacturing (159,948), and Hotels (9,310). Note that the National Agenda (2004) states that the agriculture sector employed 40,000 Jordanians and 43,000 Egyptians in 2003. The 2004 Census may not have fully recorded all temporary Egyptian workers. Assume two indirect jobs are generated for each direct sectoral job.
[xvi] European Training Foundation Report, Jordan, 2006

[xvii] *Water Resources in Jordan*, NWMP series, June 2004, page 14.

[xviii] *Water Uses and Demands*, NWMP series, June 2004, page 11.
[xix] NWMP 2004, Volume 8, Executive Summary, page 2

[xx] *Dwindling Groundwater Resources* PowerPoint Presentation, USAID-funded MWI Groundwater Project, 2007, slide 1.

[xxi] *Dwindling Groundwater Resources* ibid, comments to slide 1.

[xxii] *NWMP 2004*, Volume 5, Chapter 3.

[xxiii] *Dwindling Groundwater Resources*, ibid, slide 4.

[xxiv] *Dwindling Groundwater Resources*, ibid, comments to slide 3.

[xxv] *Dwindling Groundwater Resources*, ibid, slide 3.

[xxvi] Information provided by staff of the USAID-funded Groundwater Project at MWI.

[xxvii] *NWMP 2004*, Volume 5, Chapter 3, Figure 3.7

[xxviii] Royal Society for the Conservation of Nature website: http://www.rscn.org.jo/ConservationAzraq.asp and *Water and the Environment*, NMWP Series, June 2004, page 17

[xxix] A fossil water reservoir is not naturally recharged.

[xxx] *Water Resources in Jordan*, NWMP Series, June 2004, page 22

[xxvii] Jordan Times' Editorial, *The 60-40 Economy*, Yusuf Mansur, 3 April 2007

[xxxii] *Dwindling Groundwater Resources*, ibid, comments to slide 4.

[xxxiii] *A Water Resource Planning Model for Aqaba*, Nathans Associations for USAID-funded AZEM Project, March 2007, *Annex I, Water Demand Forecast for Aqaba*, page 1

[xxxiv] Jordan Times' Editorial, *The 60-40 Economy*, Yusuf Mansur, 3 April 2007, ibid

[xxxv] *Pricing of Water and Wastewater Services for the Water Authority of Jordan – Cost Recovery Scenarios and Action Plan*, November 2004, EcoConsult, page 2.
[xxxvi] *NWMP 2004*, Volume 6, Table 2.8.

[xxxvii] *Environmental Management Systems/Pollution Prevention Success Stories,* Reuse for Industry, Agriculture and Landscaping (RIAL) Project, CDM International for USAID, brochure, 2007.

[xxxviii] Statement by RIAL staff at meeting with SABEQ on 12 April 2007.

[xxxix] *A Water Resource Planning Model for Aqaba*, Nathans Associations for USAID-funded AZEM Project, March 2007, *Annex III, Desalination Costs*, Table 16, page 17.

[xl] Assuming low cost desalination costs of approximately JD 0.400 per m3 from AZEM Annex III, ibid, and pumping costs of JD 0.300 per m^3 **[confirm pumping costs]**

[xli] Cost estimates for the Red-Dead canal range from $3 - $4 billion. 2005 Jordan GDP was $12,729 million.

[xlii] *Strategic Management of Jordan's Water*, Ross Hagan, Water Resources and Environment Office, USAID, 2006, page 15

[xliii] Calculated from statement "The analysis results indicated that the percentage of water saving "cubic meter per capita per year" was estimated at nearly 28.1% had the new code been enforced and adopted." *Final Report 2000-2005*, Water Efficiency and Public Information for Action (WEPIA) Program,

[xliv] *Monthly Statistical Bulletin*, Central Bank of Jordan, Volume 43 No.2, Feb 2007, Table 58

Table 4. GDP by Selected Sectors (million JD)

	GDP at constant market prices (1994=100)	GDP at current market prices	Manufacturing	Mining	Agriculture
1985	3507	1971	189	66	97
1986	3700	2241	274	68	114
1987	3786	2287	293	73	135
1988	3841	2350	260	83	138
1989	3429	2425	261	155	133
1990	3419	2761	353	149	190
1991	3474	2958	347	125	214
1992	3973	3611	445	131	247
1993	4151	3884	443	107	199
1994	4358	4358	586	103	193
1995	4628	4715	607	157	174
1996	4724	4912	570	154	159
1997	4881	5138	622	170	148
1998	5028	5610	742	170	145
1999	5198	5778	761	164	116
2000	5419	5999	807	172	121
2001	5704	6364	861	176	124
2002	6034	6794	988	189	149
2003	6286	7229	1083	192	178
2004	6816	8081	1314	230	202
2005	7308	9012	1528	263	223

Source: Monthly Statistical Bulletin, Central Bank of Jordan, Table 35, www.cbj.gov.jo

[xlv] Both examples provided by Modern Farm staff to USAID-funded SABEQ staff at interviews in January 2007.
[xlvi] *NWMP 2004*, Volume 3, Chapter 2, Tables 35 and 36.